RAYTHEON

ELECTRONIC PROGRESS

SEPTEMBER
OCTOBER 1956

Hurricane Signal Up!

In this issue: PROBING THE RESTLESS ATMOSPHERE

ELECTRONIC PROGRESS

VOLUME 1 **SEPTEMBER - OCTOBER 1956** **NUMBER 2**

RAYTHEON

ELECTRONIC PROGRESS

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THE COVER

A signal of terror to mariner and landsman alike appears on our cover. The hurricane signal, red with black centers, displayed one above the other, warns of the approach of a hurricane.

Now, new radars capable of detecting tornadoes and hurricanes up to 250 miles away will help the weatherman give earlier and more accurate warnings.

Index

Weather and Raytheon	**E. L. Williams**	**1**
Probing the Restless Atmosphere	**Charles Kalayjian**	**2**
Magnetrons for Weather Radar	**Morris LaPrelle**	**5**
High Vacuum Titanium Pump	**Samuel R. Jackson**	**6**
Inventions		**7**
Raytheon Facilities	**R. L. Holden**	**8**
Publications & Papers		**9**

Calendar

Northeastern University Off-Campus Courses

	Place	*Time and Date*
		Starting week of September 13
Advanced Mathematics	**Publications Bldg.**	**Monday**
Theoretical Physics	**Waltham**	**Tuesday**
Transistor Circuit Engineering		**Wednesday**
Microwave Tubes		**Thursday**
Transients in Linear Systems		**Friday**

For information call Robert C. Storey, Extension 495, Waltham

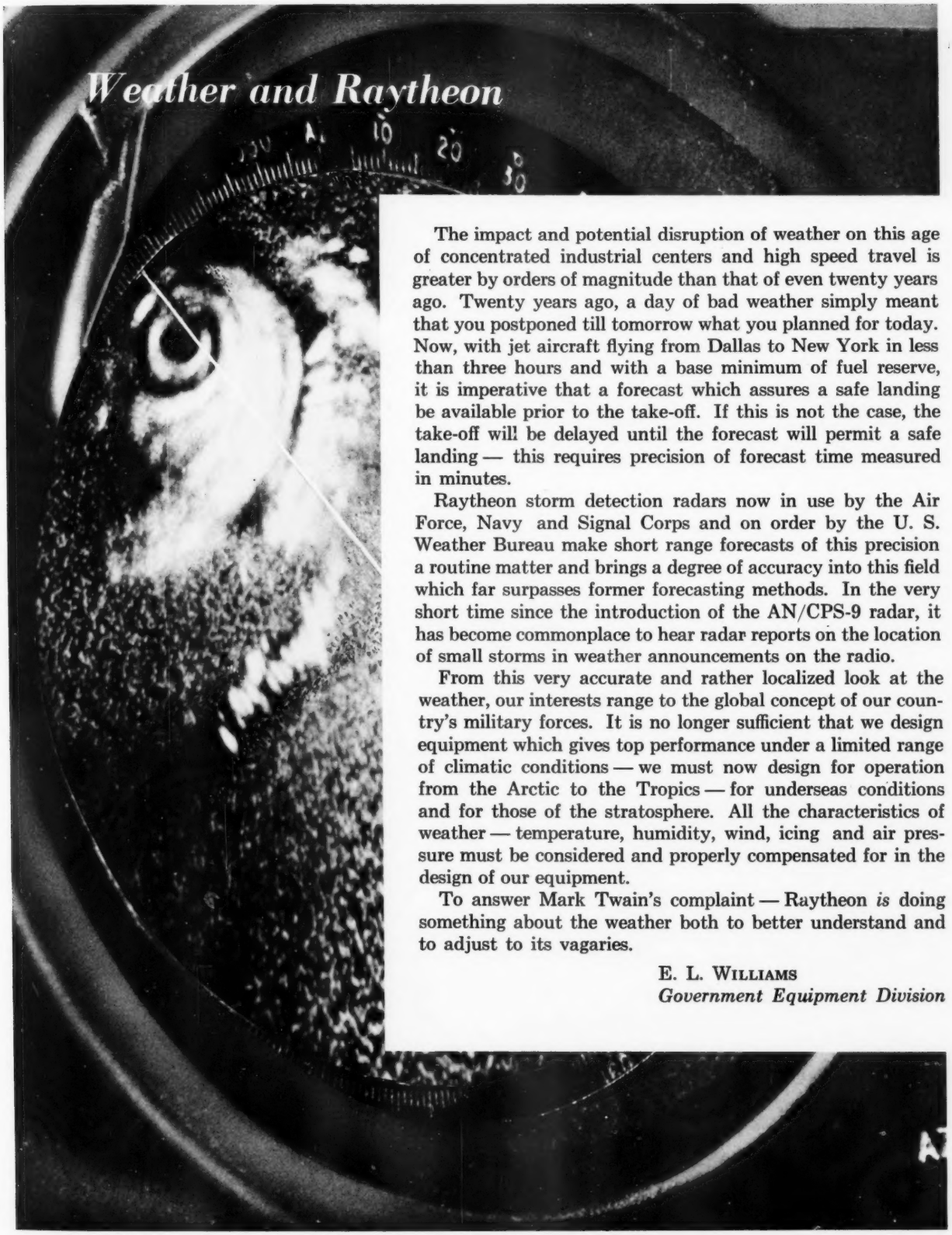
Other Seminars and Courses

Space Charge Seminar	**Research**	**As required**
Ceramics Seminar	**River Bldg.**	**October 28**

Technical Committee Meetings

	Place	*Time and Date*
Plastics	**Varies**	**2nd Tues. or Thurs. of the month**
Ferrite	**Varies**	**1st Wednesday of the month at 3:00 p.m.**
Transistor Circuit	**Research**	**As required**
Welding	**Varies**	**1st Thursday of the month at 3:00 p.m.**
Magnetic Amplifier Engineering and Scientific Co-ordinating Committee for Digital Computers	**Varies** / **Research**	**Varies** / **As required**

Technical and engineering personnel who desire further information concerning the above calendar should contact Mr. James Sterling, Research Division, Extension 2187.



Weather and Raytheon

The impact and potential disruption of weather on this age of concentrated industrial centers and high speed travel is greater by orders of magnitude than that of even twenty years ago. Twenty years ago, a day of bad weather simply meant that you postponed till tomorrow what you planned for today. Now, with jet aircraft flying from Dallas to New York in less than three hours and with a base minimum of fuel reserve, it is imperative that a forecast which assures a safe landing be available prior to the take-off. If this is not the case, the take-off will be delayed until the forecast will permit a safe landing — this requires precision of forecast time measured in minutes.

Raytheon storm detection radars now in use by the Air Force, Navy and Signal Corps and on order by the U. S. Weather Bureau make short range forecasts of this precision a routine matter and brings a degree of accuracy into this field which far surpasses former forecasting methods. In the very short time since the introduction of the AN/CPS-9 radar, it has become commonplace to hear radar reports on the location of small storms in weather announcements on the radio.

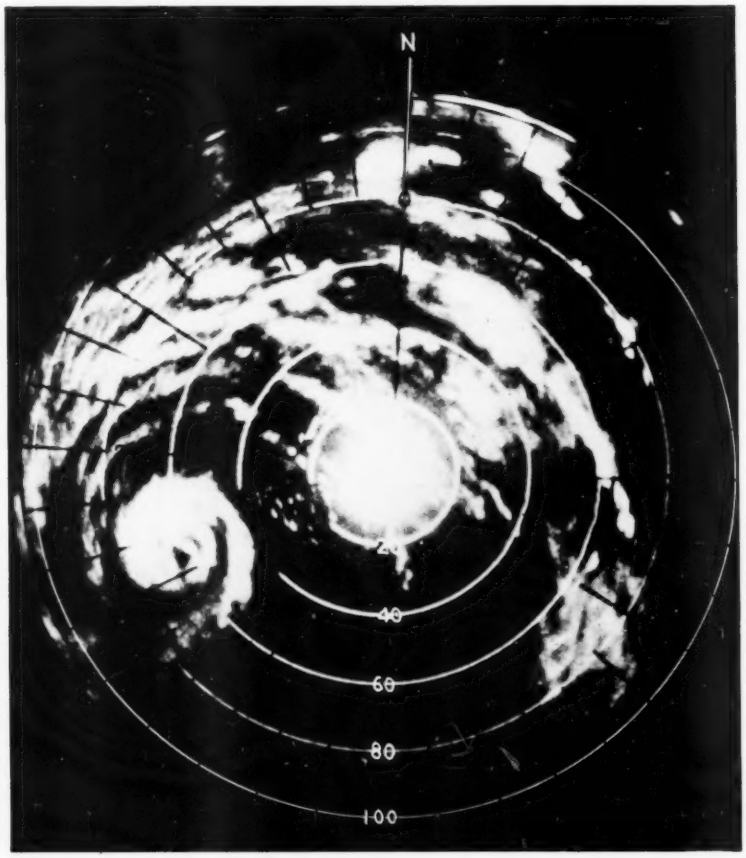
From this very accurate and rather localized look at the weather, our interests range to the global concept of our country's military forces. It is no longer sufficient that we design equipment which gives top performance under a limited range of climatic conditions — we must now design for operation from the Arctic to the Tropics — for underseas conditions and for those of the stratosphere. All the characteristics of weather — temperature, humidity, wind, icing and air pressure must be considered and properly compensated for in the design of our equipment.

To answer Mark Twain's complaint — Raytheon *is* doing something about the weather both to better understand and to adjust to its vagaries.

E. L. Williams
Government Equipment Division

Probing the Restless Atmosphere

CHARLES KALAYJIAN
Wayland Laboratory



PPI Presentation of Hurricane Ione taken on a 10 cm. radar located at Cape Hatteras, N. C. by the U. S. Weather Bureau.

THE use of radar to detect weather phenomena depends primarily on the relationship between the size of particles in the atmosphere and the wavelength employed. In 1875, Lord Rayleigh established this relationship while investigating the scattering of light by spherical particles in his studies on the color of the sky. He calculated that the scattering cross section of these particles was directly proportional to the sixth power of the diameter and inversely proportional to the fourth power of the wavelength. The significance of this relationship became apparent during the development of radar at microwave frequencies when backscatter from raindrop particles was detected by these radars. Although these reflections were of dubious value for the intended military applications, extremely detailed observation of spatial distribution of important meteorological phenomena within the range of the radar set was now possible.

The importance of these observations led to the development of a radar designed specifically for this purpose. This equipment, designated Radar Set AN/CPS-9, was developed jointly by the Signal Corps and Raytheon. Its design parameters were

based upon certain known and suspected characteristics of precipitation echoes.

The nature of these reflections differs in many respects from that obtained from an aircraft or "point target." One important characteristic is that of reflectivity, or scattering cross section, which is inversely proportional to the fourth power of the wavelength, while the reflectivity at microwave frequencies of a "point target" is nearly independent of wavelength. It is apparent from this relationship that the signal strength of precipitation echoes relative to "point targets" is much greater as the wavelength is decreased.

Another important difference is the target volume, as these targets occupy cubic miles of atmosphere. When the beam is completely filled, the volume is determined by π $(R \sin \frac{\theta}{2})^2 \frac{\tau}{2}$, where R is the range, θ the beam angle, and τ the pulse width. Increasing τ increases the echo intensity in direct proportion, being limited only by the range resolution desired and depth of the precipitation. While increasing the beamwidth does increase the volume of the targets, the signal intensity does not increase due to the accompanying reduction in antenna gain.

By substituting the product of target volume and reflectivity for the cross sectional area of the target in the radar range equation, it can be shown that the echo intensity varies inversely as the square of the range, as compared to the inverse fourth power law obtained from "point targets" when the beam is filled. However, as the range increases, line of sight limitations, coupled with the increase in cross sectional area of the beam, reduces the percentage of the target intercepted by the beam until it approaches that of a "point target" source. For maximum range detection, a narrow beam with its resultant increase in antenna gain is essential. An additional advantage of using a narrow beam is the high degree of target resolution obtained.

From these considerations the design parameters were determined on the basis of available components and the desired range detection capabilities of 250 miles. The operating frequency of 9300 mc (3.2 cm) made possible a practical antenna size to obtain a one degree conical beam, and provided the desired signal reflectivity. This was also made possible by the availability of high-powered components — a peak power output of 250 Kw at 5.0 microseconds pulse width was sufficient for detection at the desired ranges.

The meteorologist is vitally concerned with the vertical development of precipitation as well as its horizontal extent and movement. Almost all tornadoes, hailstorms and sudden squalls are associated with the thunderstorm type of structure, which develops rapid vertical convective currents. The rate and extent of the build-up indicate the severity of the atmospheric conditions and degree of turbulence. Severe thunderstorms have build-ups to over 30,000 feet, damaging hailstorms extend to over 40,000 feet, and tornadoes are very likely if the build-ups extend beyond 50,000 feet. To permit these observations, the radar antenna is capable of automatic elevation scan in addition to the conventional azimuth rotation.

The display system consists of a Range Height Indicator (RHI), an A-Scope (Signal Intensity vs. Range) with an expandable sweep to allow detailed analysis of any selected portion of the received signal, a PPI (plan-position indicator), a two-radii off-center PPI and a remote PPI. Each scope has provisions for mounting a camera and synchronizing the camera to the sweep.

The significance of a Range Height Indicator display is shown in Figure 1. As precipitation falls, indications of winds aloft are evidenced by trails of snow particles. The narrow horizontal layer of high-intensity signals, called the Bright Band, is caused by processes associated with melting snow particles and occurs below the 0°C isotherm layer. Since the dielectric constant of water is five times that of snow, the reflectivity of signals at this level

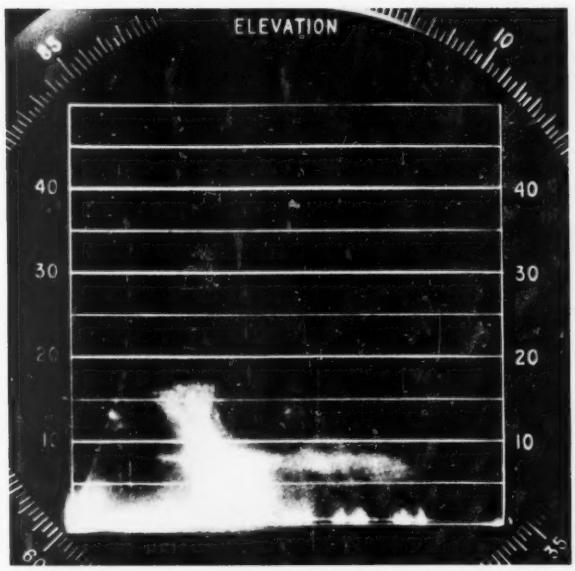


Figure 1. RHI Presentation of Bright Band observed on the Radar Set AN/CPS-9 located at Blue Hills Observatory, Milton, Massachusetts. Bright Band occurs at 8,000 feet. Photo courtesy of Geophysics Research Directorate, AFCRC.

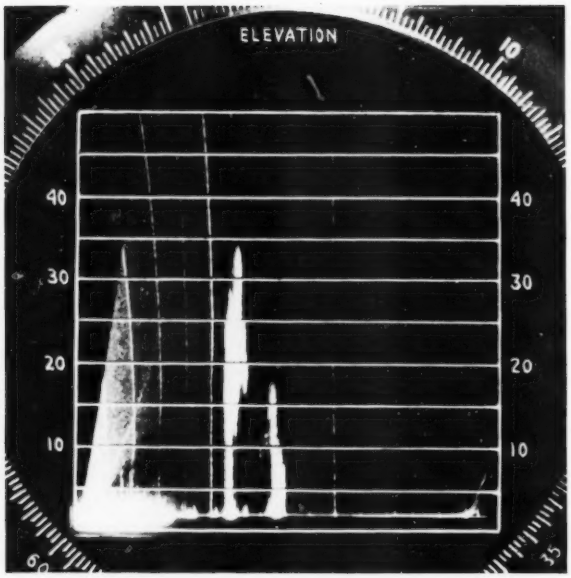


Figure 2. RHI presentation of a thunderstorm observed on the Radar Set AN/CPS-9 located at Blue Hills Observatory, Milton, Massachusetts. The depth of the storm is 5 miles as measured by the range marks. The height of the storm extends to 34,000 feet. Photo courtesy of Geophysics Research Directorate, AFCRC.

is increased. Once the particles have completely melted, the resultant particle becomes smaller and the fall velocity of these particles increases rapidly, and volume reflectivity is correspondingly reduced. The presence of the Bright Band layer indicates the level at which icing occurs, and should be avoided by aircraft. In addition, examination of the Bright Band indicates to some degree the extent of storm turbulence as the vertical convective currents extend the melting and freezing processes over considerable heights. If the convective currents are very strong, as in thunderstorm activity, the Bright Band cannot be detected. Figure 2 is an observation of thunderstorm activities; note the vertical extent of the storms and lack of Bright Band.

The wavelength of 3.2 cm, chosen for the CPS-9, appears to be nearly optimum for general weather conditions. However, under conditions of very severe precipitation, the energy is attenuated so rapidly within a storm that the full depth of the storm cannot be observed. Under these conditions a longer wavelength is more satisfactory since attenuation decreases as wavelength is increased. At 10 cm, the attenuation is sufficiently less so that full penetration of the storm is realized and the signal strength is entirely adequate. This wavelength thus appears to be nearly optimum for hurricane use: under somewhat less severe conditions a compromise wavelength of 5.4 cm has been suggested by some meteorologists. The optimum complete weather radar system as recommended some time ago by Raytheon would be one in which the wavelength could be changed quickly to meet the specific conditions and objectives of a particular time and place. The shorter wavelength would be used for general purpose in the middle and northern latitudes, and the longer wavelengths could be used when and where heavy rain densities and tropical hurricanes were prevalent.

The Weather Bureau recently awarded a contract to Raytheon for such a system with interchangeable transmitters and associated waveguide assemblies for operation at 3.2, 5.4 and 10 cm. The reflector size will be increased to 12 feet in diameter when operating at 10 cm, to obtain a beamwidth of 2.0 conical degrees. Since the immediate concern of the Weather Bureau is the detection of hurricanes, the early systems will be furnished to operate at 10 cm.

The successful outcome of any campaign depends in large measure on the intelligence obtained regarding the movements of the opponent, and the subsequent use of this information. The use of Weather Radar makes possible observations regarding the mysterious movements of the storm, assisting man to better determine the tactics to employ.

Magnetrons for Weather Radar

MORRIS LaPRELLE

Applications Engineering
Microwave and Power Tube Operations

THE use of magnetrons as the microwave power source for radar systems has been universally standard since the early days of World War II. During and since the war, magnetrons have been developed for frequencies from 450 megacycles to 24,000 megacycles, power levels from fractional watts to megawatts, and for both continuous and pulsed operation. Tubes, in general, are designed to fill a specific need, but many, after lab and field experience, are found to be useful for other applications. Thus, magnetrons for use in weather detection radar systems imposed no serious burden of special tube development, but rather the proper selection of attainable characteristics and the combination of these in an integrated tube design.

The development of the Raytheon CPS-9 Storm Detector Radar brought about the first requirement for such a tube. An X-band magnetron was needed which would supply 250-kilowatt pulses of 0.5 microsecond duration with a duty cycle of 0.0005. Operation at duty cycles up to 0.001 and pulse durations up to 5 microseconds was also specified. Since no available tube met all these requirements, the QK-221 magnetron (now designated the RK6002) was specifically designed for this application.

The development of airborne weather radar systems for storm detection and avoidance added weight, size and proven reliability requirements to the choice of magnetrons. Moreover, it was felt that while X-band frequencies of operation were suitable for some systems, the C-band frequencies would be preferred where it was desirable to see deeper into cloud and storm formations, especially if the user was not concerned with formations having small precipitation particles. Admitting a variety of needs, systems manufacturers produce both X and C-band types, leaving the choice up to the customer depending on his intended application.

For the X-band airborne system, an existing Raytheon magnetron, the 2J55, is being used directly without tube design changes. Its 40-kilowatt pulsed power is adequate for the range requirements. When the tube was selected, over 20,000 magnetrons of this type had been shipped and a long history of reliability in military airborne radar established.

At the time, no C-band tube existed which could adequately fulfill the requirements of the desired companion system. To meet this need, the QK-456 was designed using an existing C-band tube, the QK-396, as a prototype but with substantially increased power output. It is interesting to note the QK-396 had previously evolved through several tube type stages from the 2J55 used in the X-band system. In its final form, the QK-456 operates at 5400 megacycles with a minimum pulsed power of 75 kilowatts and a guaranteed radiation life of 2000 hours.

For equipment intended for use in studying cloud structures and formations, it was found that higher frequencies were desirable. For such applications, the QK-308, which oscillates at 16,000 megacycles, and the QK-389, which oscillates at 24,000 megacycles, have proven satisfactory and are presently in use.

Although magnetrons for weather radar pose no severe design problems, it must be realized that the relative ease of design stems almost directly from Raytheon's comprehensive tube development programs. These programs have provided the background know-how which so simplifies the design of magnetrons for weather radar.

High Vacuum Titanium Pump

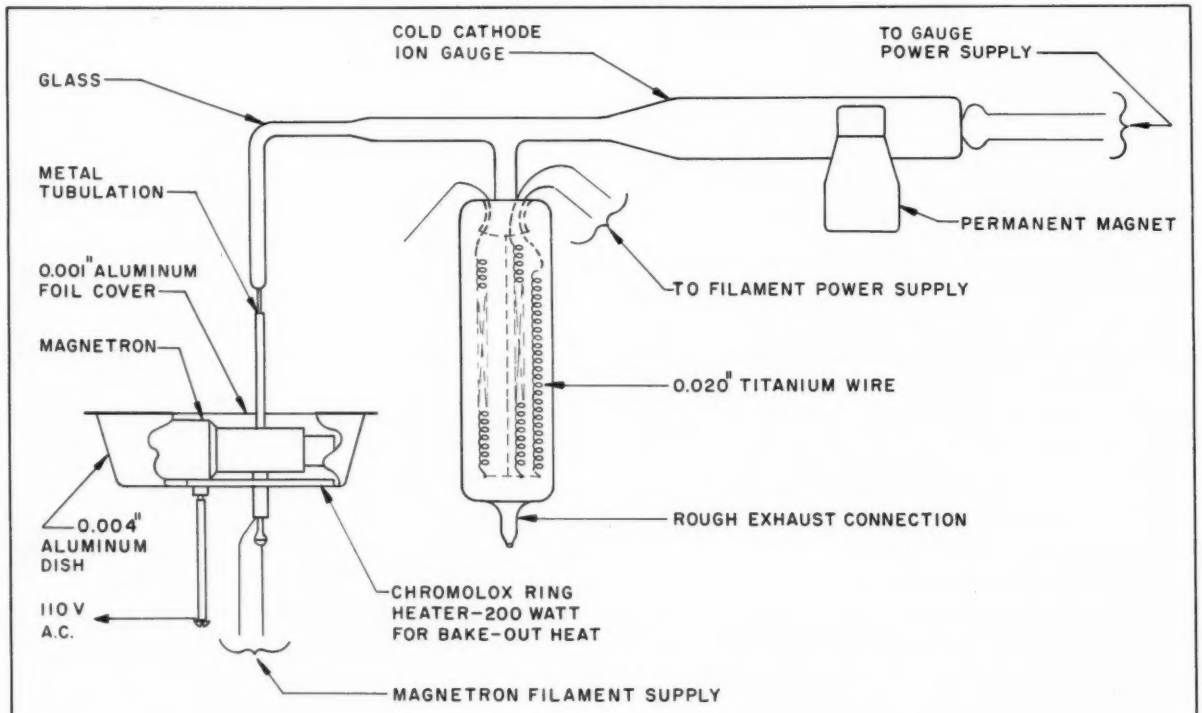
SAMUEL R. JACKSON

Special Tube Development Laboratory
Microwave and Power Tube Operations

ONE of the properties of the element titanium which is important to the electron tube engineer is its extraordinary ability to getter the residual gases normally encountered in electron tubes. The availability of inexpensive titanium wire has greatly increased the feasibility of supplanting the high vacuum diffusion pump in situations where it is needed for electron tube exhaust.

In a recent experiment conducted by the Microwave and Power Tube Research and Development Laboratory eight magnetron oscillators were successfully exhausted using titanium to remove the gases remaining after rough pumping each tube. The only variation from the usual exhaust procedure for such tubes was that in lieu of the usual

Titanium Pump System



SYSTEM USED TO EXHAUST MAGNETRON OSCILLATOR USING TITANIUM GETTER PUMP

diffusion pump a glass bulb containing a small filament of pure titanium wire (0.02" dia.) was sealed onto the system which, after roughing out, was sealed off tight. The physical details of this system are shown in the line drawing.

By heating the titanium filament to approximately 1500°C the gas pressure, as indicated by the cold cathode ion gauge, quite suddenly falls at a decelerating rate and in about 15 minutes reaches an approximate value of 5×10^{-6} mm Hg. Bakeout and cathode breakdown are then carried out accompanied by a temporary rise in pressure which may go as high as 5×10^{-4} mm Hg. After cooling the tube to room temperature the pressure will be less than 10^{-7} mm Hg if no leak is present. Another advantage of the titanium pump is seen here; since the titanium bulb is not a fast pump, a leak larger than 10^{-6} micron-liters/sec will result in a pressure in the 10^{-6} mm range or higher.

Ordinarily the magnetron tube is sealed off from the system as soon as it reaches room temperature; however, if not sealed off but allowed to stand overnight, the pressure will drop to less than 1×10^{-8} mm Hg proving that the titanium pump is an effective pump if not a fast one.

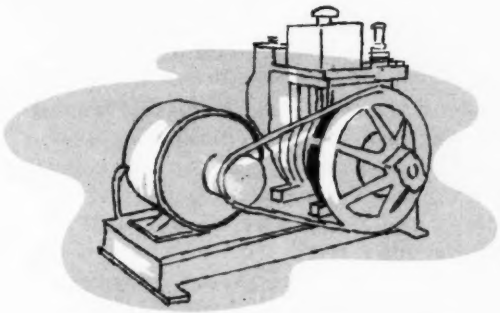
One practical improvement of this method is to wrap the titanium wire onto a larger tungsten wire. Since the melting point of titanium is not much greater than the required operating temperature, the composite wire avoids the danger of burning out the titanium filament without sacrificing any of its effectiveness. It is also known that improved performance can be obtained by arranging elements that will ionize the gas in the presence of the titanium. Such a device is called an Evapor-ion Pump and was first demonstrated by physicists at the University of Wisconsin. A commercial pump of this type has been developed by the Consolidated Vacuum Corporation.

The pumping or gettering action of titanium is believed to take place when the titanium vapor originating in the hot filament condenses onto the relatively cool walls of the bulb. In just a short time this deposit completely blackens the bulb making it difficult to see the filament. This finely divided titanium sponge metal rapidly adsorbs gases, especially hydrogen, onto its large surface. If emission from a cathode held slightly positive with respect to the titanium sponge ionizes the gas, these ions are forced into the sponge so as to produce a greater gettering effect. Heating of this sponge drives a small amount of the adsorbed gas off again, but the process is positively reversible so that the gas is readsorbed when the sponge is cooled.

The chief advantage afforded by the titanium method of exhaust is simplification of pumping facilities. In addition there are the following advantages:

(1) There is no oil which might enter the system to poison the cathode of the tube or result in a soft vacuum after seal off.
(2) Small leaks can be detected at a time when repair is still feasible.
(3) Higher ultimate vacuum is possible.

There is one disadvantage; i.e., without the ionizing arrangement the titanium sponge has no gettering effect toward helium and other noble gases.



Inventions

Congratulations to the following persons for their valuable contributions to Raytheon's portfolio of inventions:

Name	*Field of Invention*
Blattel, A., Spyut, A. B.	Sealing-In Method
Bonia, W. J., Olbrych, J. E.	Portable Amplifier
Bourassa, F. J.	Diode Packaging
Clampitt, L., Zawada, F.	Magnetron Anode
Dench, E. C.	Carcinotron Tuning
Dench, E. C.	Tuning Device
Dench, E. C., Derby, P. P.	Countermeasures Device
Ellis, R. C., Jr.	Preparation of Silicon
Eriksen, W. T., Letaw, H., Jr.	Semiconductor Surface Treatment
Geier, L. W.	Cathode Centering Device
Gross, T. A. O.	Ferrite Isolator
Grover, T., Hergenrother, R. C., Luftman, A. S.	Periscope Viewer
Happ, W. W.	Heat Sink
Hergenrother, R. C.	Interdigital Line Termination
Hynes, F. J., Schuck, J. F., Jr.	Glaze and Metalization Maturing
Lanza, C.	Multivibrator
Parziale, E. V.	Power Transistor
Prescott, R. S.	Computer Amplifier
Redgrift, H. I.	Solder Flux
Reed, J., Wheeler, G. J.	Balanced Duplexer
Rizzi, P. A., Shaw, G. C.	Cut-Off Filter
Rizzi, P. A.	Ferrite Circulator
Rosen, H. A.	Ferrite Modulator
Sheehan, W. E.	Neutralized Amplifier
Weil, T. A.	Jamming Device
Wheeler, G. J.	Switch

Raytheon Facilities

Environmental Test Laboratory

R. L. HOLDEN

Equipment Operations

EQUIPMENT and devices manufactured by Raytheon must perform efficiently and reliably in a variety of environmental conditions. Military operations are geographically so far ranging that equipment must function in the dry heat of the desert, the humid heat and torrential downpours of the tropics and the extreme cold and snow conditions of the arctic. Operational needs often intensify already severe environmental conditions. The ambient temperature for equipment in an airplane under the sun on a tropic air base reaches extremes well above the outside ambient.

In order to assure that Raytheon equipment meets various JAN and MIL specifications the Government Equipment Division's Environmental Section under L. E. Stafford is equipped and staffed to conduct environmental tests. Facilities are located at the Wayland Laboratory and at Waltham. In general the test chambers in Wayland are used for small parts and components while those at Waltham can accommodate complete systems.

Military Standards have been established which indicate the probable extreme weather conditions to which military equipment may be exposed. Some of the extremes for ground equipment are listed below.

Operation between temperature extremes of −80°F (−62.2°C) to 125°F (51.7°C). Short-term storage and transit at extremes of −80°F (−62.2°C) and 160°F (71.1°C).

Operation, short-term storage and transit at dew point extremes of −65°F (−53.9°C) and 85°F (29.4°C).

Extreme Precipitation — Operation under a 32 inch rainfall in a 24 hour period with the temperature of both air and water at 70°F (21.1°C) and a rate of fall as follows: 12 inches in 11 hrs. 55 min., 2 inches in 5 min., 11 inches in 11 hrs. with 40 mph wind speed, and 7 inches in 1 hour. Short-term Storage and Transit is the same but applicable only to packaging.

This indicator unit of a "Pathfinder"® small-boat radar must pass grueling environmental tests to win engineering approval as a Raytheon product.

Penetration and Abrasion — Blowing Snow crystals, 1 to 3 mm. diameter; wind 40 mph; temperature, 0°F. (Both Operation and packaging for Short-term Storage and Transit).

Blowing Sand, 0.18 to 0.30 mm. diameter; wind 40 mph at a height of 5 feet; temperature, 100°F. (Both Operation and Short-term Storage and Transit.)

Blowing Dust, 6×10^{-9} grams/cubic centimeter, .0001 to .01 mm. diameter; blowing at 40 mph at a height of 5 feet; temperature 70°F (21.1°C). (Both Operation and Short-term Storage and Transit.)

Extreme Atmospheric Pressure — Operation from 31.30 to 14.94 in. of mercury. Short-term Storage and Transit from 31.30 to 11.1 in. of mercury.

Extreme Snow Load — Snow Load standards are for horizontal surfaces and vary with the usage of the equipment up to 40 lbs./sq. foot for a large mobile equipment on which snow can accumulate and usually is not removed between snowfalls.

An appended table lists the test chambers currently in use, together with the pertinent characteristics of each. All these chambers have ports through which test cables may be connected to test equipment located external to the chamber. Most of the chambers also have windows for the visual monitoring of equipment operation under environmental conditions, while four of the larger chambers have built-in control shafts to facilitate operation of equipment from outside the chamber.

The Environmental Section is also equipped to perform many other environmental tests including altitude, shock, vibration, acceleration, salt spray, immersion, supply line (voltage and frequency), power (consumption and power factor), thermal shock and life.

RAYTHEON TEST CHAMBER FACILITIES

Test Chamber	Inside Dimensions	Relative Humidity	Temperature Limits	Maximum Altitude	Comments
Magher	10′x12′x9′	20% to 100%	−40°C to +65°C	Not applicable	Continuous recording of wet and dry bulb temperatures.
Tenney	4′x8′x5′	20% to 100%	−70°C to +90°C	70,000 ft.	Automatic programming and continuous recording of wet and dry bulb temperatures.
Tenney	30″x36″x38″	20% to 100%	−10°C to +90°C	Not applicable	
Tenney	30″x36″x38″	20% to 100%	−10°C to +90°C	Not applicable	
Kold Hold	30″x34″x30″	20% to 100%	−65°C to +85°C	70,000 ft.	Continuous recording of altitude and wet and dry bulb temperatures.
Bowser	3′x3′x3′	20% to 100%	−65°C to +90°C	65,000 ft.	
Bowser	3′x3′x3′	20% to 100%	−70°C to +90°C	70,000 ft.	
Tenney	14″x14″x14″	No Control	−73°C to +120°C	Not applicable	
Tenney	24″x24″x19″	No Control	−100°F to ambient	Not applicable	

Publications & Papers

"Radiography in Production Control and Inspection of Reliable Subminiature Tubes"

ERIC A. KOLM

National Meeting of Society for Non-Destructive Testing

Cleveland, Ohio, October, 1956

Abstract: Precision radiography as a nondestructive testing and production control device has recently been introduced in the reliable electron tube industry. As a result, new concepts of image resolution detail and speed of operation have been developed in conjunction with the necessary machinery. Through such methods it is possible to detect internal flaws of microscopic welds made between hair-like wires as well as many other defects possibly causing catastrophic tube failure. Principles of fractional focus x-ray targets are discussed and compared with larger sources together with special effects obtained from certain x-radiation wavelength and related variables.

Fluoroscopy with closed circuit television is evaluated in terms of sensitivity and detail resolution required for microscopic weld analysis. Some of the actual results obtained are shown together with a discussion of skills required to interpret these results and those needed for other inspection methods.

"Designing Storage Tube Equipment"

J. A. BUCKBEE and A. S. LUFTMAN

Electronics Magazine

July, 1956

Abstract: Special cathode-ray tubes for storing information are useful in frequency-bandwidth conversion, MTI radar and data storage and analysis. High-voltage power supply, video amplifiers, sweep and blanking generator, focus-current regulator and staircase raster generator used with storage tube are described. Typical use is TV transmission over telephone lines.

"The Kramers-Kronig Relations for Gyrotropic Media"

ERNST SCHLOEMANN

The Physical Review

Abstract: The Kramers-Kronig relations between the real and imaginary parts of a complex susceptibility are generalized and applied to gyrotropic media. It is found that the diagonal elements of the susceptibility tensor obey the same relations as an isotropic susceptibility. The off-diagonal elements obey modified relations. The generalized Kramers-Kronig relations are applied to sublattice resonance in ferromagnetics. Together with a loss criterion, they determine the analytic form of the circular susceptibility in the loss-less case. A simple formula describing a lossy gyromagnetic medium with several resonances is given.

"Optimum Design of Power Transformers with Unbalanced DC Loading"

THOMAS A. WEIL

Electronics Magazine and for presentation at the Electronics Components Symposium

Abstract: The design of power transformers with unbalanced DC loading is not generally as straightforward a procedure as other types of transformer design. Usually, the designer assigns an arbitrary portion of the available flux density to be DC flux density, and gaps the core appropriately; the remaining portion of the available flux density is then utilized for AC, or useful, flux density. The gap prevents the DC from saturating the core, but cannot eliminate DC flux density entirely, so there is always a compromise.

This paper provides a graph showing the optimum choice, and in addition the graph gives directly other factors which usually have to be determined by calculation or by trial and error. Thus, the optimum design of transformers with unbalanced DC in the windings becomes a direct and fast procedure.

"The Tri-Port Conical Scan Antenna"

E. WANTUCH and L. A. KAISER

I. R. E. Convention

Los Angeles, California, August, 1956

Abstract: Various laboratories have shown that conical scanning rates of 100 cps. and higher are desirable for several reasons. Amplitude fluctuations of target echoes introduce angular tracking noise in conical scan systems, since amplitude comparison in a given plane is sequential rather than simultaneous. In addition, as the closing velocities of modern aircraft increase, angular position information must be obtained more rapidly.

Mechanical difficulties increase very rapidly if conventional designs are lobed at rates greater than 60 to 80 cps. These problems have stimulated interest in the family of tri-scan antennas discussed in this paper.

◀ ▶

The abstracts listed represent only a fraction of those publications made during the past two months. Publication activity is increasing rapidly and currently numbers about 13 articles or talks per month.

RADAR THAT PUTS THE FINGER ON STORMS

Something *is* being done about the weather! The first long-range radars designed specifically for the U.S. Weather Bureau are being engineered and built by Raytheon. Each radar pin-points storms within a radius of 250 miles, measures distance, direction, height and course—makes possible more reliable advance warnings. Storm Detector Radars, each covering 200,000 square miles, will be linked eventually in a nation-wide network.

Reliable, accurate, versatile—Raytheon Storm Detector Radar promises far greater knowledge of atmospheric conditions and precise analysis of storm structures. Here is another striking example of how Raytheon's "Excellence in Electronics" is contributing to the security, productivity and well-being of the American people.

RAYTHEON *Excellence in Electronics*

RAYTHEON MANUFACTURING COMPANY
WALTHAM 54, MASSACHUSETTS

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